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Architectural Implications of Cloud Computing

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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 24 OCT 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE Architectural Implications of Cloud Computing				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University ,Software Engineering Institute,Pittsburgh,PA,15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 34	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Agenda

Basic Cloud Computing Concepts ←

Architectural Implications of Cloud Computing

Final Thoughts



Cloud Computing

“A large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet.”



jaworski.net

I. Foster, Y. Zhau, R. Ioan, and S. Lu. “Cloud Computing and Grid Computing: 360-Degree Compared.” Grid Computing Environments Workshop, 2008.

“A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

National Institute of Standards and Technology (NIST), 2011.



Cloud Computing Types

Software-as-a-Service (SaaS)

Platform-as-a-Service (PaaS)

Infrastructure-as-a-Service (IaaS)

Based on Type of Capability

Public Cloud

Private Cloud

Based on Who Can Access Resources



Infrastructure-as-a-Service (IaaS)

Mainly computational infrastructure available over the internet, such as compute cycles and storage

Allows organizations and developers to extend their IT infrastructure on an on-demand basis

Examples of IaaS Providers

- Amazon Elastic Compute Cloud (EC2)
 - Provides users a special virtual machine (AMI) that can be deployed and run on the EC2 infrastructure
- Amazon Simple Storage Solution (S3)
 - Provides users access to dynamically scalable storage resources
- IBM Computing on Demand (CoD)
 - Provides users access to highly configurable servers plus value-added services such as data storage
- Microsoft Live Mesh
 - Provides users access to a distributed file system; targeted at individual use



z.about.com



Platform-as-a-Service (PaaS)

Application development platforms that allow the usage of external resources to create and host applications of a larger scale than an individual or small organization would be able to handle



vertoda.files.wordpress.com

Examples of PaaS providers

- Akamai EdgePlatform
 - Large distributed computing platform for web application deployment (focus on analysis and monitoring of resources)
- Force.com
 - Platform to build and run applications and components bought from AppExchange or custom applications
- Google App Engine
 - Platform to develop and run applications on Google's infrastructure
- Microsoft Azure Services Platform
 - On-demand compute and storage services as well as a development platform based on Windows Azure
- Yahoo! Open Strategy (Y!OS)
 - Platform to develop and web applications on top of the existing Yahoo! Platform (focus on social applications)

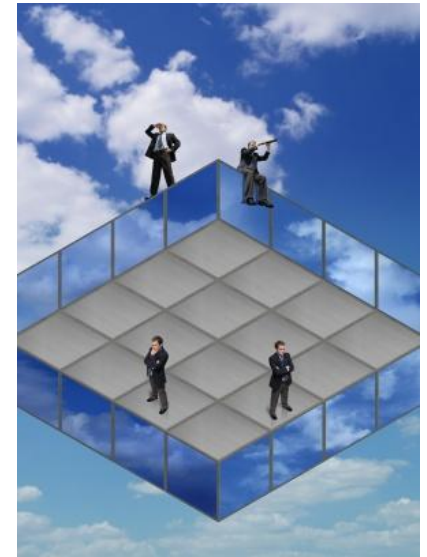


Software-as-a-Service (SaaS)

Model of software deployment in which a third-party provider licenses an application to customers for use as a service on demand

Examples

- Google Apps
 - Web-based office tools such as e-mail, calendar and document management tools
- Salesforce.com
 - Full customer relationship management (CRM) application
- Zoho
 - Large suite of web-based applications, mostly for enterprise use



cloudtp.com



Cloud Computing Types — Based on Access

Public

- Offered as a service, usually over an Internet connection
- Typically charge a pay-per-use fee
- Users can scale on-demand and do not need to purchase hardware
- Cloud providers manage the infrastructure and pool resources into capacity required by consumers

Private

- Deployed inside the firewall and managed by the user organization
- User organization owns the software and hardware running in the cloud
- User organization manages the cloud and provides cloud resources
- Resources typically not shared outside the organization and full control is retained by the organization

PERSPECTIVE

**Cloud
Consumer**

**Cloud
Provider**



Drivers for Cloud Computing Adoption

Scalability	Organizations have access to a large amount of resources that scale based on user demand
Elasticity	Organization's can request, use, and release as many resources as needed based on changing needs
Virtualization	Each user has a single view of the available resources, independently of how they are arranged in terms of physical devices
Lower Infrastructure Costs	The pay-per-use model allows an organization to only pay for the resources they need with basically no investment in the physical resources available in the cloud. There are no infrastructure maintenance or upgrade costs
Availability	Organizations have the ability for the user to access data and applications from around the globe
Collaboration	Organizations are starting to see the cloud as a way to work simultaneously on common data and information
Risk Reduction	Organizations can use the cloud to test ideas and concepts before making major investments in technology
Reliability	In order to support SLAs (service-level agreements), cloud providers have reliability mechanisms that are much more robust than those that could be cost-effectively provided by a single organization



Barriers for Cloud Computing Adoption

Security	The key concern is data privacy: organizations do not have control of or know where their data is being stored
Interoperability	A universal set of standards and/or interfaces has not yet been defined, resulting in a significant risk of vendor lock-in
Resource Control	The amount of control that the organization has over the cloud environment varies greatly
Latency	All access to the cloud is done via the internet, introducing latency into every communication between the user and the environment
Platform or Language Constraints	Some cloud environments provide support for specific platforms and languages only
Legal Issues	There are concerns in the cloud computing community over jurisdiction, data protection, fair information practices, and international data transfer



Agenda

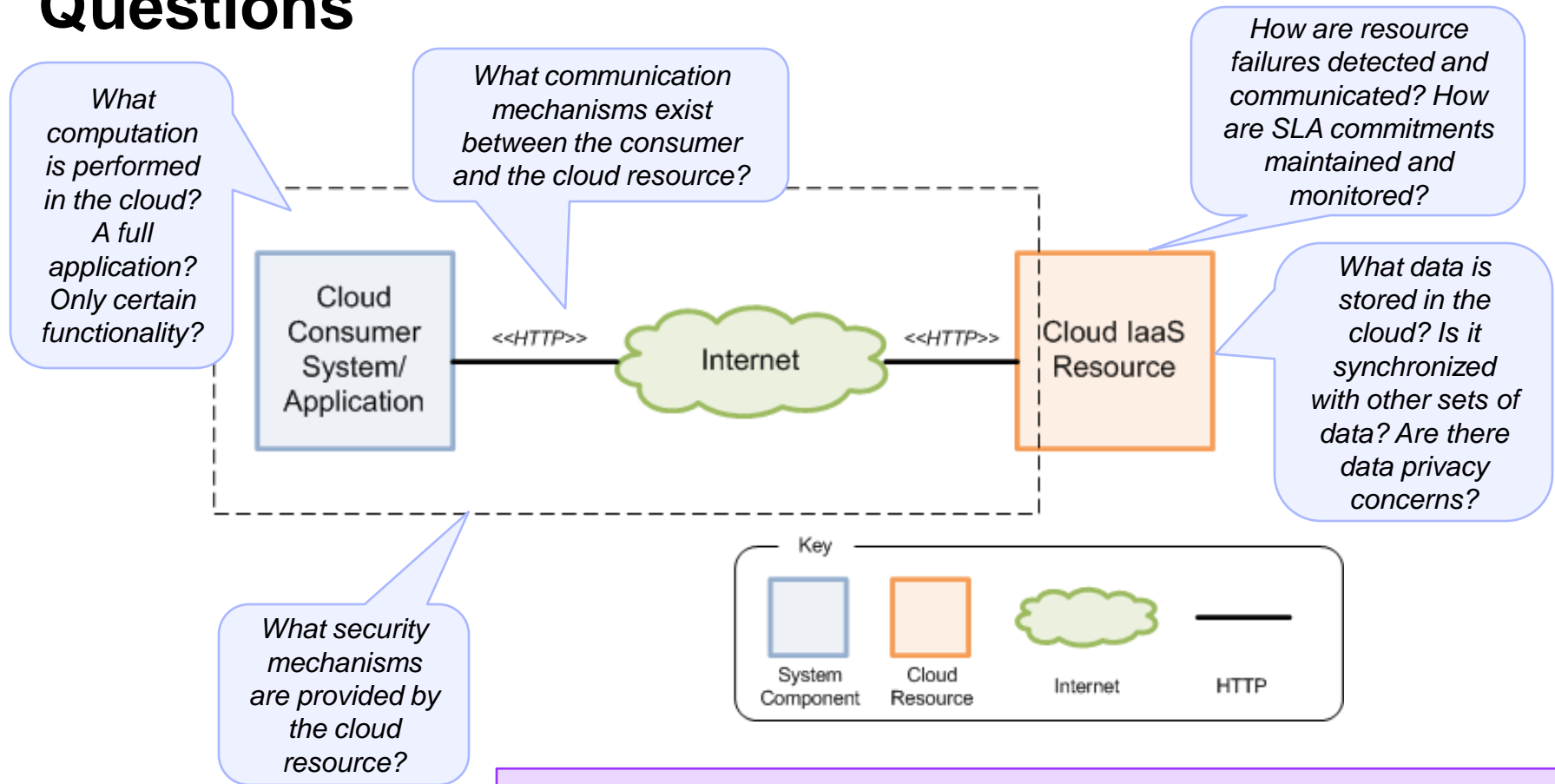
Basic Cloud Computing Concepts

Architectural Implications of Cloud Computing ←

Final Thoughts



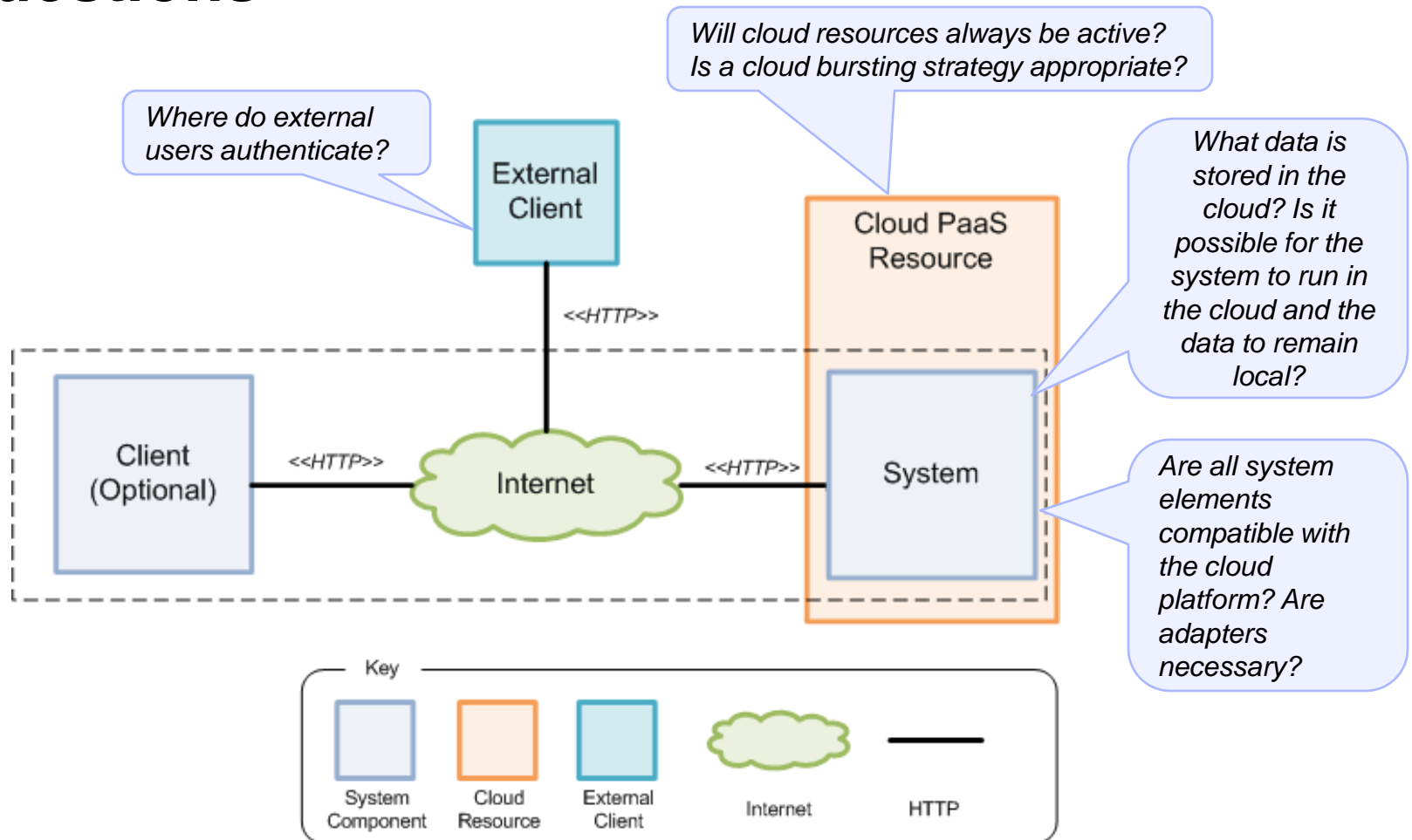
IaaS: Examples of Architecture and Design Questions



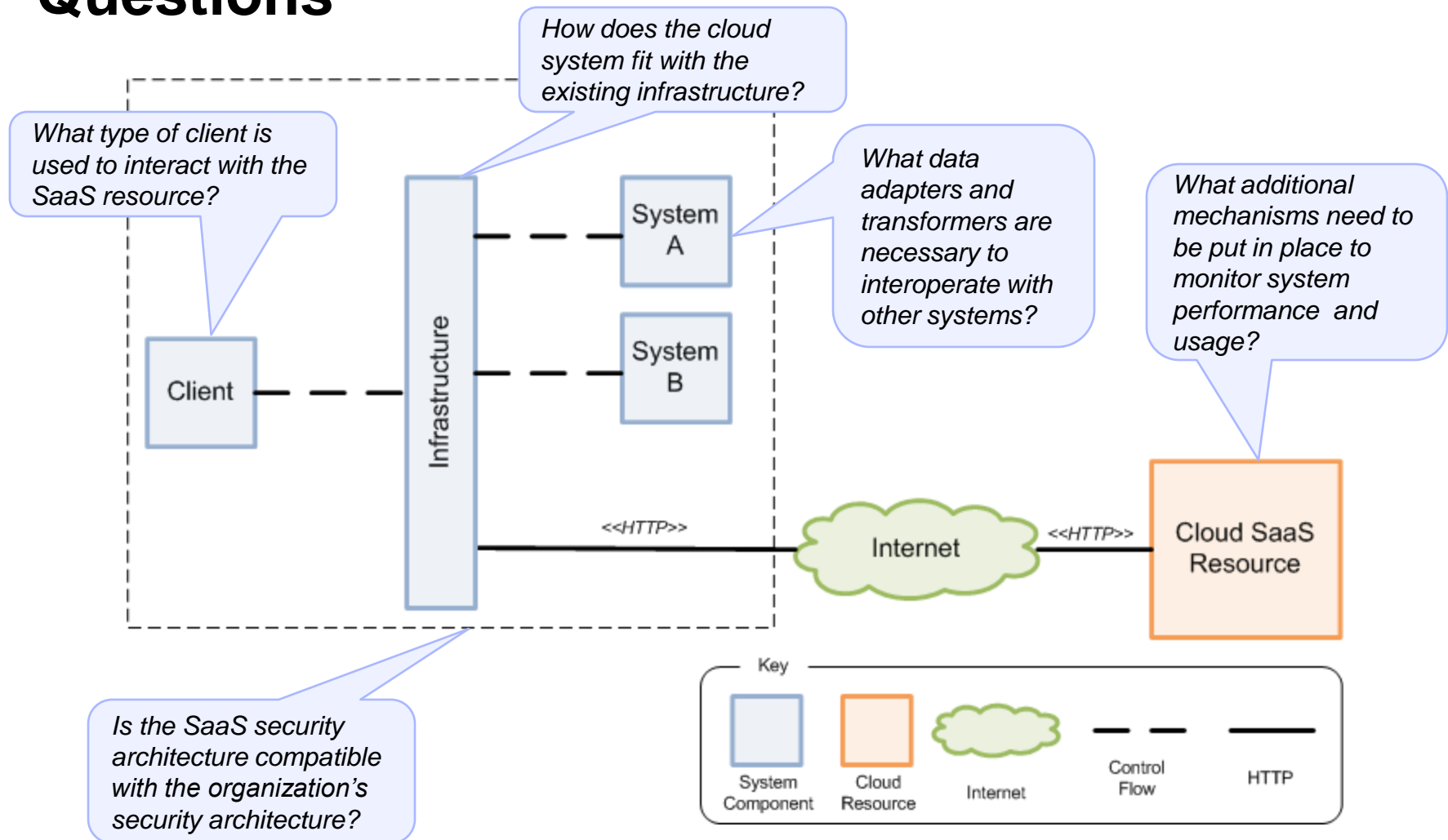
Systems residing in the cloud or using resources from the cloud will have to be designed and architected to account for lack of full control over important quality attributes



PaaS: Examples of Architecture and Design Questions



SaaS: Examples of Architecture and Design Questions



Cloud Consumer

Example Decision # 1: Data Model

Typical decisions of a distributed environment

- Local vs. Remote
- Total vs. Partitioned
- Distributed vs. Centralized
- Active Replication vs. Passive Replication
- Data Security Model

Challenges

- Data privacy
- Data synchronization
- Performance



www.jasonkolb.com



Cloud Consumer

Example Decision # 2: User Authentication Model

Authentication is the mechanism by which consumers and providers prove to one another that they are acting on behalf of specific users or systems

Typical decisions of a distributed, multi-organizational environment

- Local vs. Remote Authentication
- Single Sign-On or Separate Authentication
- Local or Remote Identity Data
- Authentication Method

Challenges

- Incompatible authentication methods
- Physical security of identity data
- Synchronization of identity data
- Auditing



blogs.verisign.com



Cloud Consumer

Example Decision # 3: Allocation of Functionality

Decisions depend on the type of cloud implementation

- What functionality to deploy in the cloud?
- What functionality has to be implemented in addition to the functionality offered by the cloud provider?
 - Security
 - Management
 - Abstraction layers, e.g. data access, transformations, adapters



leogrilo.files.wordpress.com



Cloud Consumer

Example Decision # 4: Cloud Bursting

Refers to a system that is designed for average load, but is capable of load balancing to a cloud when it reaches its full capacity

Decisions

- Activation, initialization and de-activation of the cloud resource
- State and data synchronization
- Computational elements to determine full capacity
- Computational elements for monitoring load and usage



mccallioncom425.files.wordpress.com



Cloud Consumer

Example Decision # 5: Cloud Resource Management

Decisions

- Elements for failure detection and communication
- Elements for SLA monitoring
- Logging: where, what and when



blogumn.com



Cloud Provider

Example Decision #1: Multi-Tenancy ₁

Mainly in SaaS implementations, a tenant is an organization that makes use of cloud resources

Multi-tenancy requires

- Awareness of tenant context: the capability of recognizing the identity of the tenant requesting the resources based on message information as well as configuration data
- Data isolation: tenants should only have access to their own data
- Performance isolation: resource performance should conform to service-level agreements, regardless of the load on the system

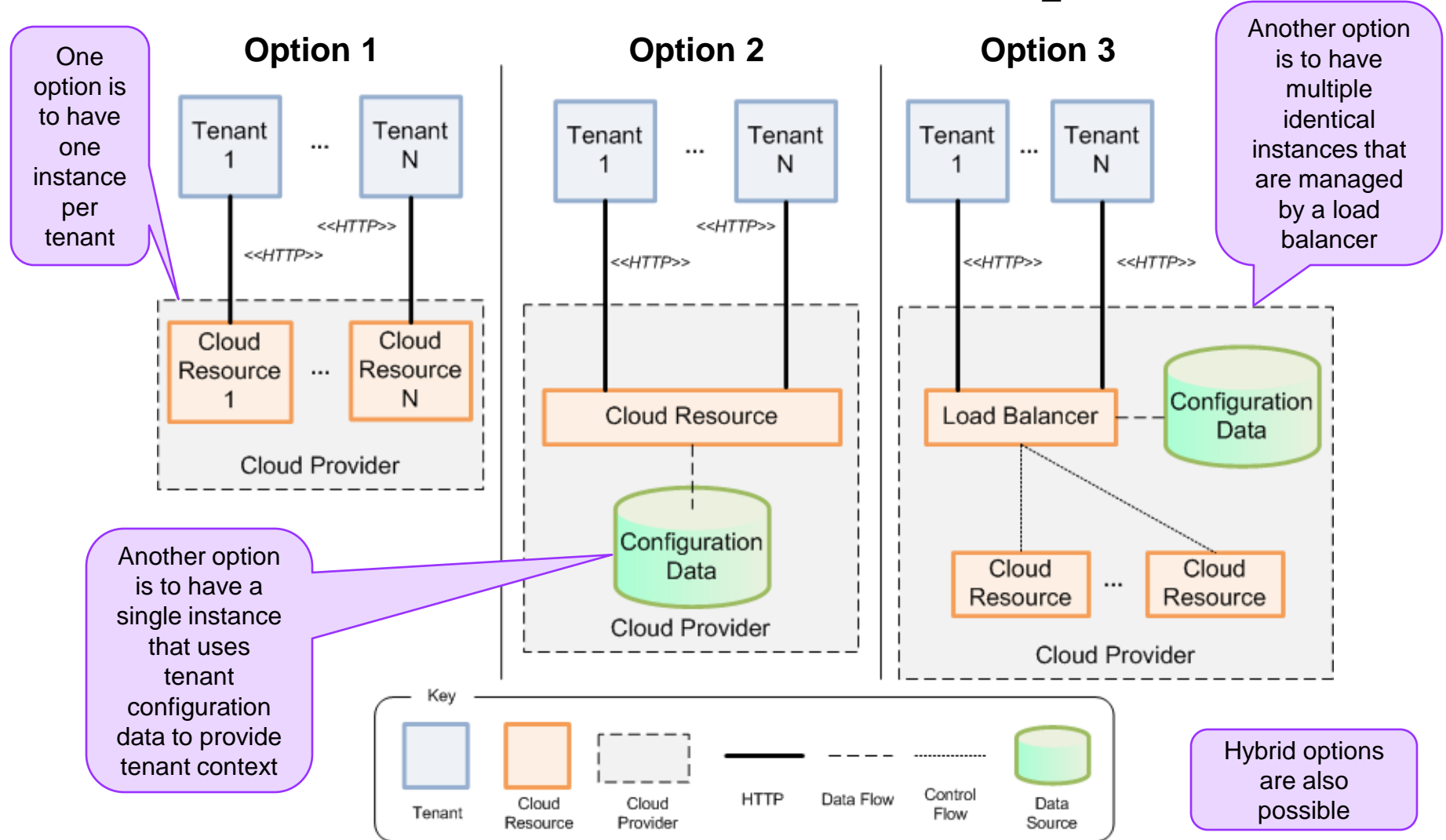


i.zdnet.com



Cloud Provider

Example Decision #1: Multi-Tenancy ₂



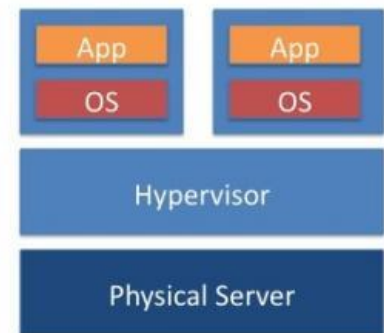
Cloud Provider

Example Decision #2: Virtualization Strategy ₁

Virtualization in general is the abstraction of computing resources, e.g.

- Network virtualization: division of available bandwidth into channels that can be assigned to a particular resource in real time
- Storage virtualization: combination of physical storage devices into what appears to be a single storage device , e.g. SAN (storage area network)
- Server virtualization: hiding of server resources (number and identity of individual physical servers, processors, and operating systems) from server users, e.g. VMs (virtual machines)

Server Virtualization Example



news.cnet.com/i/bto/20090528/Virtualization_stack_270x258.jpg

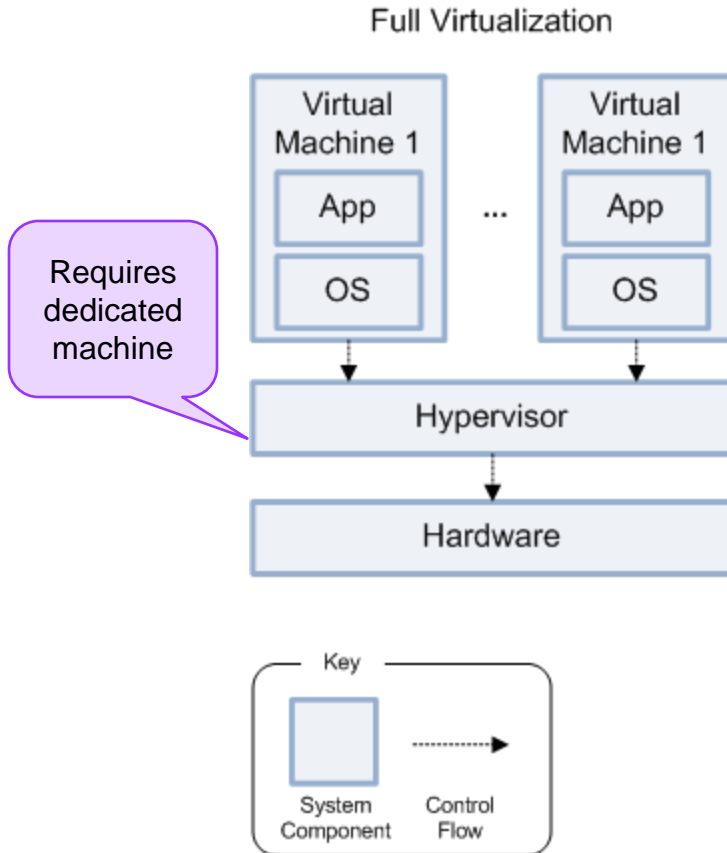


Cloud Provider

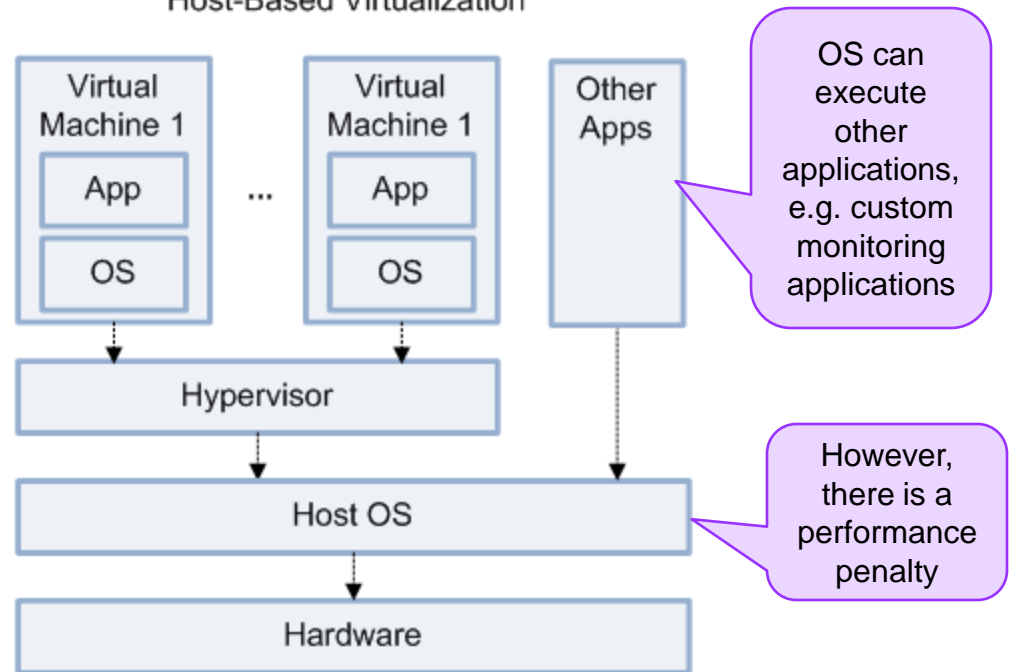
Example Decision #2: Virtualization Strategy ₂

Server Virtualization Example

Full Virtualization



Host-Based Virtualization



Main question is “How and when are virtual machines deployed, started, initialized, de-activated, replaced, managed and terminated?”

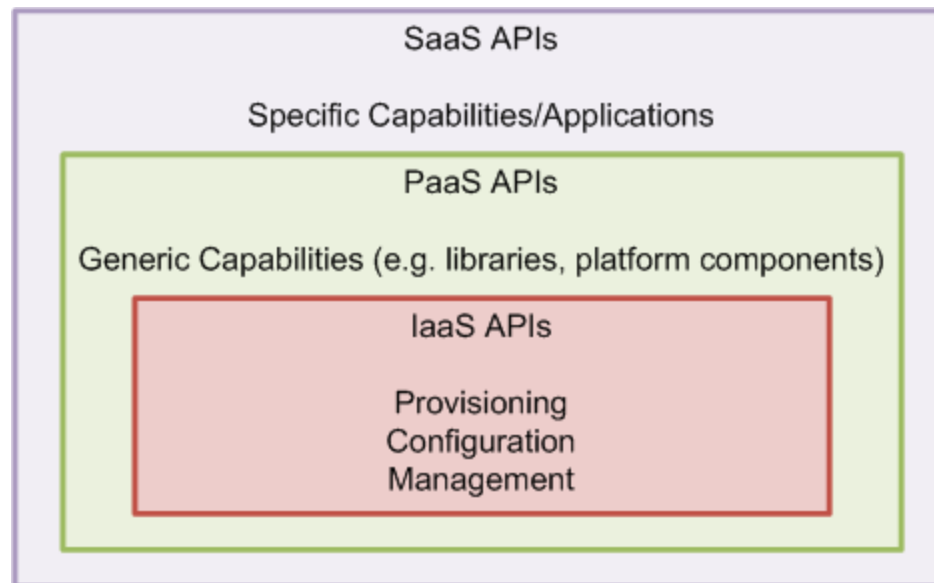


Cloud Provider

Example Decision #3: Resource Interfaces ₁

Cloud APIs are not yet standardized, so each cloud provider has its own specific APIs for managing its services

Currently, most Cloud APIs are SOAP- or REST-based



Cloud Provider

Example Decision #3: Resource Interfaces ₂

Supported Protocols

Operations

- Functionality
- Configuration
- Management

QoS Support

- Security
- Usability
- Configurability

Sample Amazon EC2 Operations (IaaS)

- Create Image
- Stop Instances
- Create Security Group
- Monitor Instances

Sample Google App Engine Operations (PaaS)

- Upload Application Code
- Authenticate User
- Send E-mail

Sample Zoho.com Operations (SaaS)

- Set Up Application
- View Application Usage Data
- Embed in “X”



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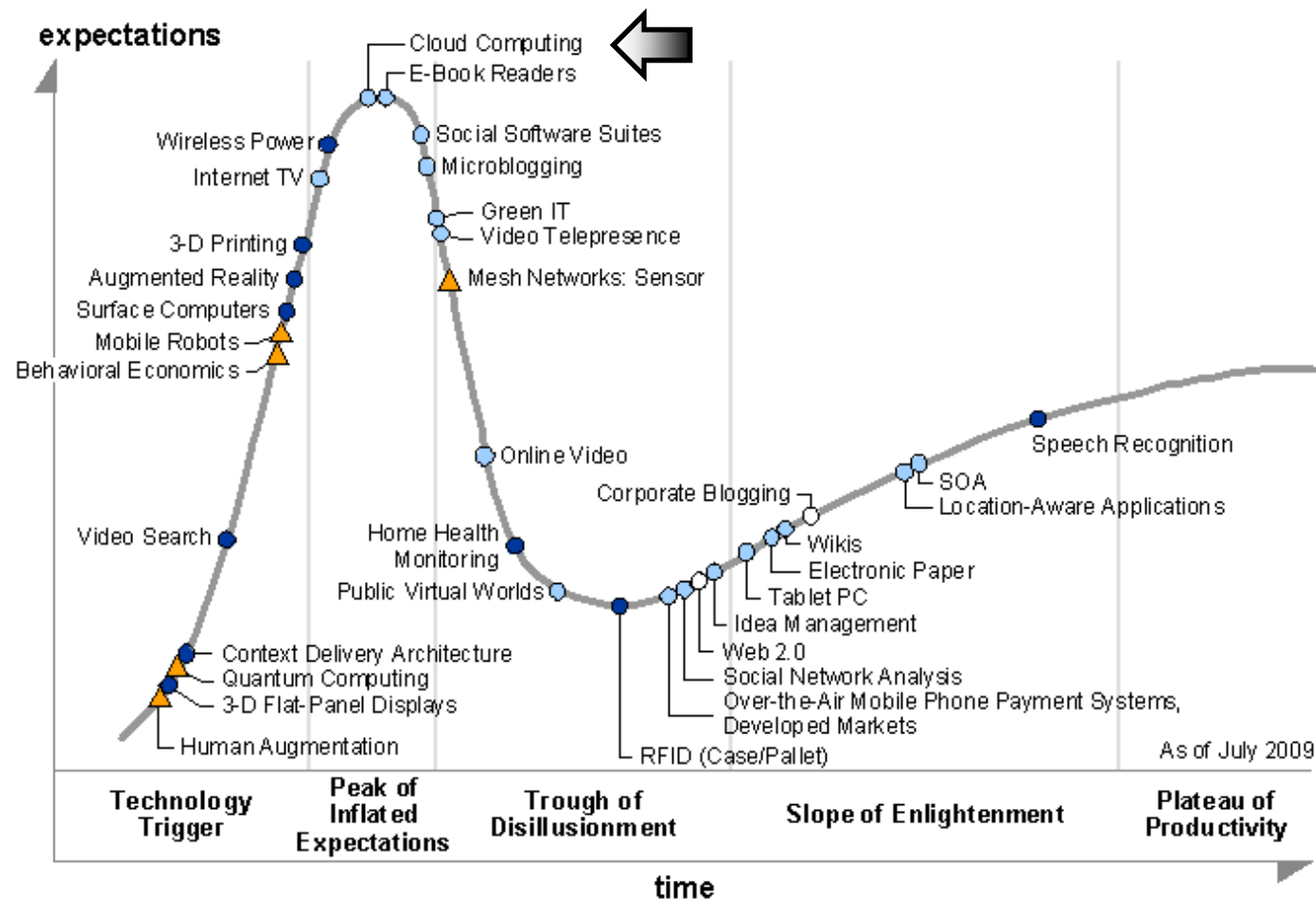
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Cloud Computing is at the “Peak of Inflated Expectations”



Years to mainstream adoption:

○ less than 2 years

● 2 to 5 years

● 5 to 10 years

▲ more than 10 years

○ obsolete

⊗ before plateau

Source: Gartner, Hype Cycle for Emerging Technologies, 2009



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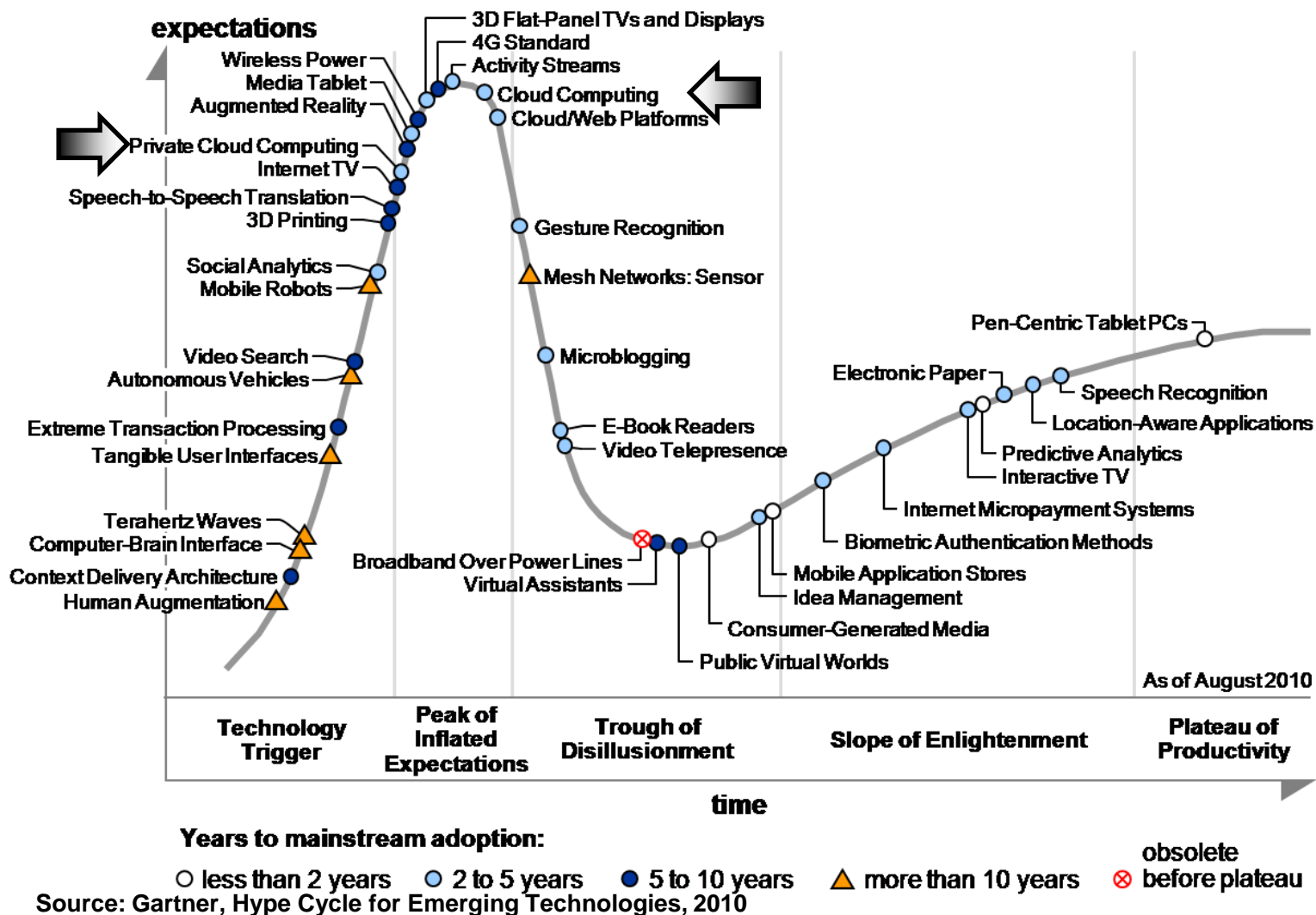
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The Concept of Private Clouds is Starting to Appear



Final Thoughts ₁

Cloud Computing is in essence an **economic model**

- It is a different way to acquire and manage IT resources

There are multiple cloud providers—**the cloud is real**

- Currently most cloud consumers are small enterprises
- Large enterprises are exploring private clouds
- The number of providers will most probably grow as people start seeing greater savings and improvements to reduce adoption barriers

Cloud Computing adoption requires **cost/benefit/risk analysis** to determine

- What resources to move to the cloud (if any)
- What situations warrant use of cloud resources, even for one-time situations
- Implementation of private clouds vs. usage of public clouds
- What risks are associated with using resources on the cloud
- What risks are associated to providing resources in the cloud



Final Thoughts ₂

Decisions from a cloud consumer perspective depend on

- Required control level
- Required security level
- Compatibility with local infrastructure

Decisions from a cloud provider perspective depend on

- Market/user characteristics
- Established SLAs
- Available technology

In general, these are not fully technical decisions

- Processes — especially engineering practices
- Governance
- Cost/Benefit analysis



askbobbyrankin.com



Cloud Provider and Tool References

- 3tera: <http://www.3tera.com/>
- Akamai EdgePlatform: <http://www.akamai.com/html/technology/edgeplatform.html>
- Amazon Elastic Compute Cloud (EC2): <http://aws.amazon.com/ec2/>
- Amazon Simple Storage Solution (S3): <http://aws.amazon.com/s3/>
- Eucalyptus Systems: <http://www.eucalyptus.com/>
- Force.com: <http://www.salesforce.com/platform/>
- Google App Engine: <http://code.google.com/appengine/>
- Google Apps: <http://www.google.com/apps/intl/en/business/index.html>
- IBM Computing On Demand: <http://www-03.ibm.com/systems/deepcomputing/cod/>
- Microsoft Azure Services Platform: <http://www.microsoft.com/azure/>
- Microsoft Live Mesh: <http://www.mesh.com/>
- Salesforce.com: <http://www.salesforce.com/crm/products.jsp>
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- Yahoo! Open Strategy (Y!OS): <http://developer.yahoo.com/yos/intro/>
- Zoho: <http://www.zoho.com/>



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Q&A

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